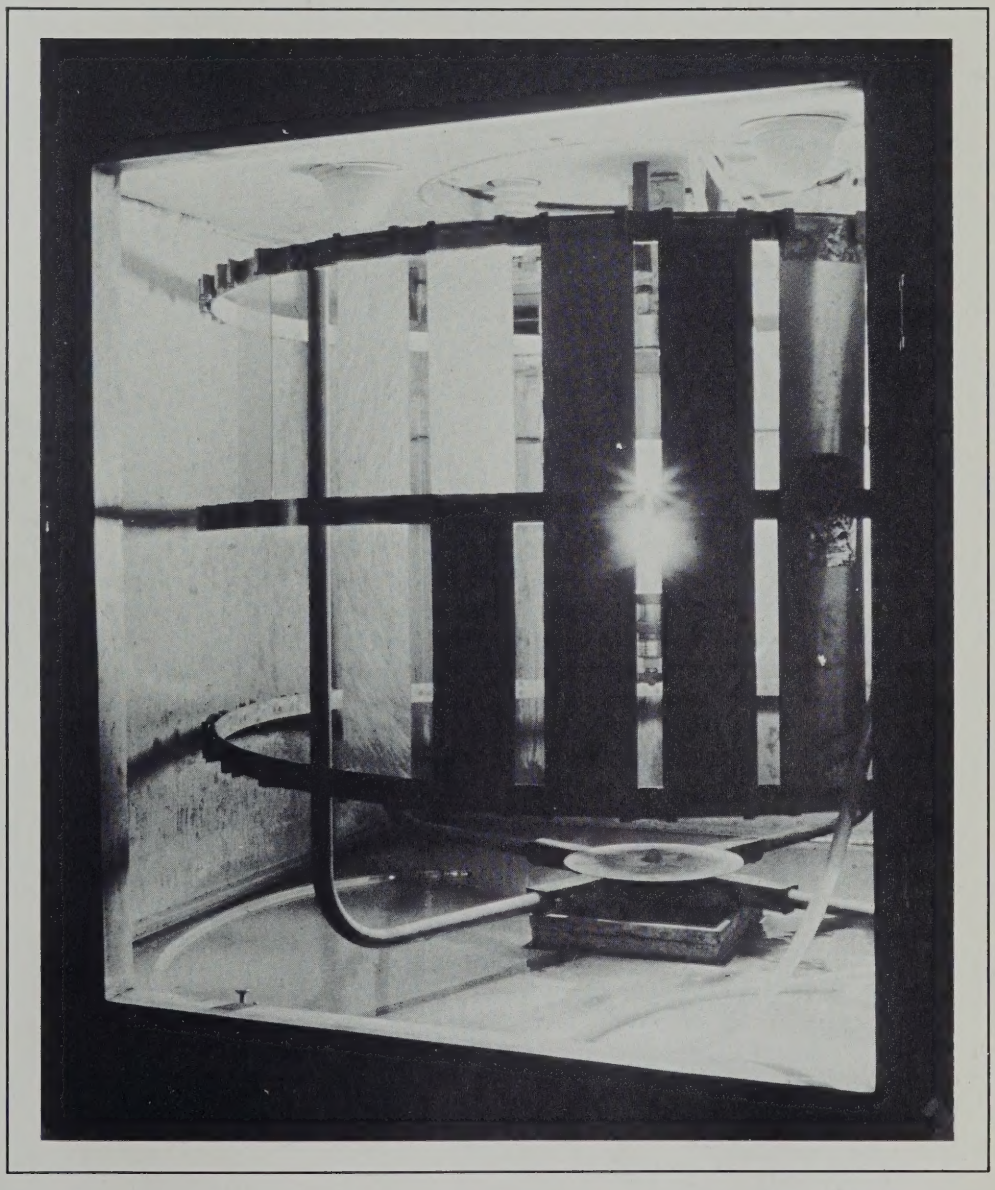
NATIONAL BUREAU OF STANDARDS *June/1969*

Technical News Bulletin



U.S. DEPARTMENT OF COMMERCE

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NATIONAL BUREAU OF STANDARDS

Technical News Bulletin

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U.S. DEPARTMENT OF COMMERCE
Maurice H. Stans, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

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COVER: This xenon arc weathering machine provides simulated solar radiation to irradiate plastic and paint specimens. Studies are underway to improve such machines by correlating outdoor and artificial weathering data *(See page 143.)*

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology
- Center for Radiation Research
- Center for Computer Sciences and Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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Richard Radlinski turns on instruments used to find out what happens to brakes in normal use and in certain kinds of failure.

Braking Systems Research Program

AUTOMOBILES, FOR DECADES AN ESSENTIAL PART of the American way of life, are frequently used with little thought for maintenance until failure occurs. This is particularly true of brakes, the wearing components of which are hidden from the user's sight. Braking systems are now being more closely examined because of the increase of high-speed travel on improved highways, sometimes by cars bearing or towing heavy loads.

Repeated sudden stops under these conditions are a severe test of brake systems. Partly in consequence, brake systems are now undergoing their first changes in basic design since acceptance of the hydraulically actuated system in the 1930's. Needed are performance standards for evaluating these new braking systems.

The National Bureau of Standards has studied many aspects of automobile operation in the past, including standardization of octane ratings in the 1940's [1] and studies of tire durability and its measurement up to the time of the creation of the Department of Transportation. The new Department sponsors automotive research by the NBS Office of Vehicle Systems Research on braking systems, tires, and occupant restraint systems.[2] The automotive performance requirements and test methods being developed for DOT's National Highway Safety Bureau will become part of Federal motor vehicle safety standards applied to automobiles sold in the United States.

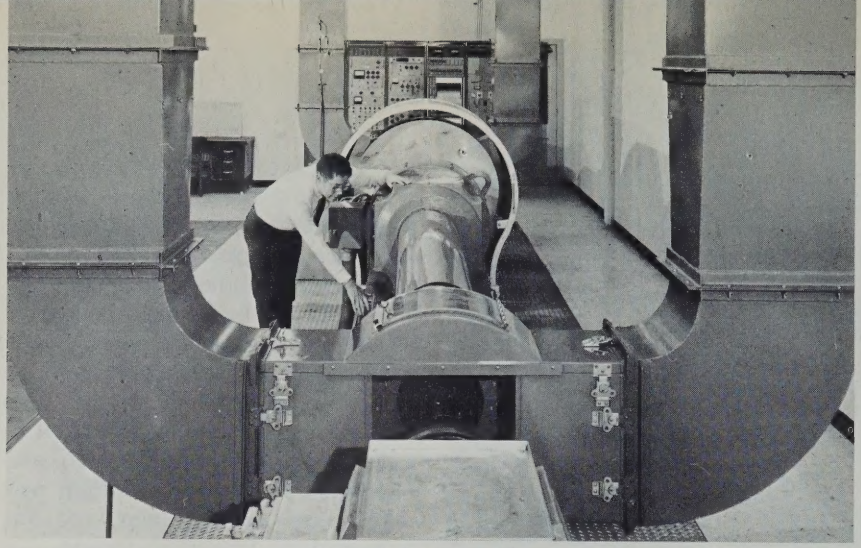
The OVSR braking systems program, established in 1967 under Robert J. Forthofer, includes work in three general areas: on-the-road performance, laboratory performance of brakes and lining material, and standards for brake fluid and other braking system components. These programs are expected to lead to standards for brake linings and pads that are more stable and resistant to fading, for better brake control systems, and for brake fluids that perform better at both high and low temperatures.

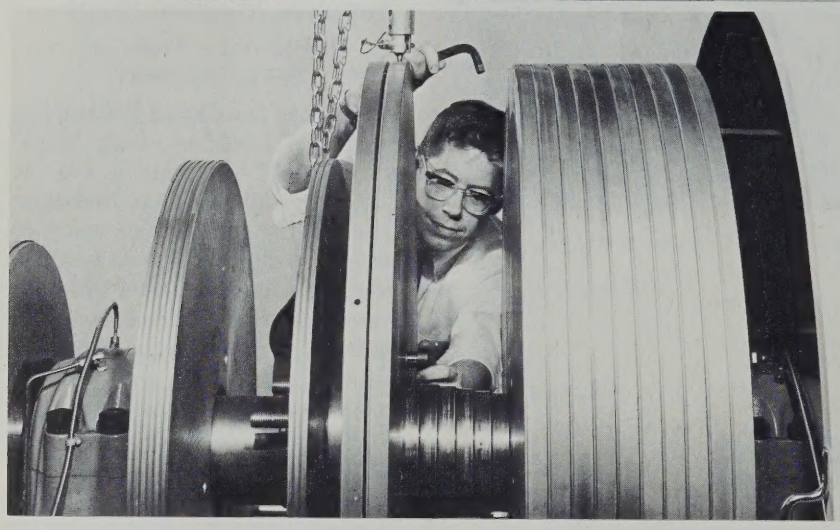
Laboratory Tests of Brake Systems

OVSR has installed a brake dynamometer, a machine which "runs" auto "wheels"—without a car attached—and applies their brakes, to measure brake performance under reproducible laboratory conditions. The amount of energy imparted to brakes by stopping the dynamometer shaft is known from the inertia of its components. This can be programed to simulate the driving conditions desired for evaluating the durability, reliability, and operating characteristics of brake systems.

The dynamometer consists of a 36-foot long mechanical assembly with a centrally mounted motor and a brake test position at each end, a motor-generator power supply for the motor, a control and recording console, and a ducted brake cooling system. The rotating system is accelerated to the desired speed (simulating road speeds to 125 mph) by the 125-hp motor and slowed or stopped by the brakes under test. The inertia of the rotating system can be adjusted to simulate vehicle weights from 900 to 14 000 pounds by adding the desired number of steel disks to the shaft.

Brake assemblies to be tested are mounted on massive tailstocks at each end of the dynamometer, so that the wheel studs mate with sockets on the ends of the dynamometer shaft. Each tailstock contains transducers to measure the individual brake torque exerted during deceleration, and the brakes are fitted with thermocouples for measuring temperatures during





Above: The brakes tested at each end of this dynamometer are driven by the centrally mounted motor through shafts running the length of the machine.
Below: John Preston bolts an inertial weight on the shaft of the dynamometer for brake tests. Selection of appropriate disks can simulate vehicle weights of 900 to 14 000 pounds.

tests. A slip clutch is mounted on the shaft between the inertial mass and one test station to allow one "wheel" to turn more slowly than the other one, simulating tire slip or wheel lock-up. This unusual feature will permit testing antilocking brake systems currently being developed.

The dynamometer can be set to operate automatically in test cycles having preset shaft speeds, inertial load, brake actuating pressures or torques, cooling air velocities, and cycle times. A drum programer automatically carries out the test sequence to completion or until a brake malfunction occurs, in which case the test is automatically terminated. Data are collected on a 12-channel strip chart recorder mounted in the control console.

Provision has been made for later addition of another two-station brake dynamometer coupled with the existing unit. The dynamometer will then be able to test all four brakes of a vehicle simultaneously.

Brake Lining Tests

The OVSR braking systems laboratory includes some of the same apparatus used by manufacturers of cars and brake components to measure the friction and wear characteristics of brake lining and pad materials. A friction materials test machine and a FAST (Friction Assessment Screening Test) machine measure the performance of these materials on brake drums and disks at various loads, speeds, and temperatures. One OVSR mission is to verify that these tests are meaningful indicators of performance in use.

Vehicle Road Testing

A popular model passenger vehicle has been instrumented to measure braking system performance and to develop test techniques. The test vehicle's instruments include a "fifth wheel" attached to the rear bumper to measure stopping distance and vehicle speed, gages indicating brake fluid line pressure and power-assist vacuum, and thermocouples and pyrometers measuring temperature of brake linings and brake fluid at selected points. Vehicle deceleration while braking is measured with both a U-tube device and an electronic servo accelerometer system. A strip chart recorder is utilized to record selected data.

Wet brake performance and recovery characteristics can be measured by flooding the brakes with a built-in pressurized watering system before test stops.

Shutoff valves are installed in the brake fluid lines to each wheel so that various modes of partial brake failure can be simulated. Road tests with one or more brakes disabled can be made to determine how the vehicle will react with a partially effective braking system.

Since much of the road testing is done at high speeds, the vehicle is equipped with a roll bar and test personnel wear crash helmets in addition to standard seat belts and shoulder harnesses.

Brake Fluids Laboratory

Hydraulic braking systems for cars were developed early in the century and were widely and successfully used in racing cars in the early 1920's although they did not replace mechanical brakes on passenger cars until a decade later. The first fluids used

successfully in hydraulic brake systems were castor oil thinned with solvents such as diacetone alcohol. Now the fluids are formulated of various polyglycol compounds, with inhibitors and antioxidants added to improve stability and to prevent corrosion.

The severe demands on today's braking systems are countered by compounding brake fluids to resist extremes of service and high temperatures and to have low corrosivity. The fluid properties must be balanced between extremes—high boiling point and fluidity at low temperatures. The ideal brake fluid will not only be satisfactory when placed in service, but will maintain the desired properties despite aging, heat, and the introduction of water.

Water is the enemy of brake systems in several ways. It seems to be impossible to keep it from penetrating the braking system, where it can lead to corrosion of metal parts and possibly disable the system in freezing weather. To prevent this, modern fluids are formulated to be compatible with water and to absorb rather than reject it.

NBS research confirms that with aging and increasing water content a fluid's boiling point falls drastically and it becomes more viscous in cold weather. Because of this it is important that standards take this degradation into consideration; also needed are criteria and field test procedures for determining when a fluid has become so degraded that it should be replaced. These become more necessary as the passage of time brings cars that are heavier, faster, and more powerful; highways that are more crowded and more demanding; and body designs that hide brakes from cooling airflow. Even engineering advances can add to demands on brake fluid; the disk brake brought with it higher localized temperatures and consequent greater stress on the brake fluid and other components.

The first industry specification for brake fluids was developed during World War II, and in 1947 the Society of Automotive Engineers published its first brake fluid standard.

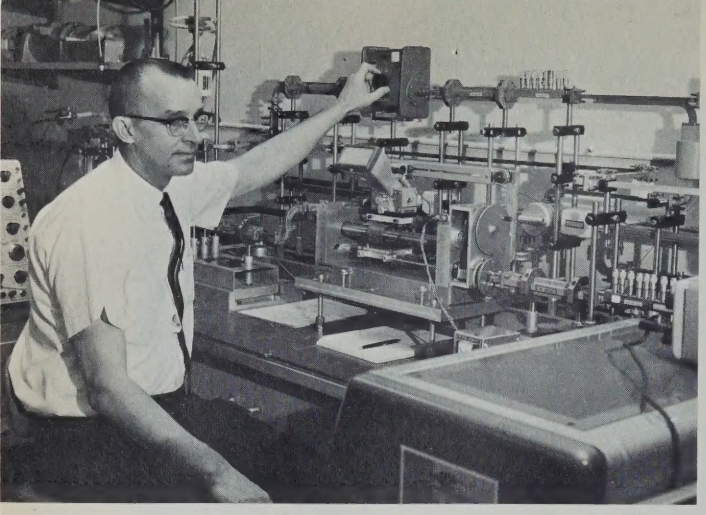
Above: Phillip Orticke, Jr., operates automatic titration apparatus measuring the water in a sample of brake fluid, even a small amount of which seriously affects performance.
Below: John Preston measures the thickness of lining on automotive brakes being tested on a dynamometer. The drum fits over these brakeshoes during the test and is rotated through the wheel studs.

Government entered the picture in 1953 with the enactment in Minnesota of the first compulsory standard for brake fluid. Federal legislation in 1962 empowered the Secretary of Commerce to set and publish specifications for motor vehicle brake fluids in interstate commerce. In 1966 this authority was transferred to the Secretary of Transportation, whose Department now supports the NBS auto safety research programs.

The immediate goals of the OVSR brake fluid research are: to determine if existing tests are meaningful in relation to actual service, to evaluate and improve measurement reproducibility, and to develop better tests where possible. The laboratory analyzes and tests brake fluids using gas-liquid chromatography, infrared spectroscopy, and chemical and physical procedures. The Bureau's efforts are directed toward establishing performance requirements.

At present the Bureau is developing evaluation capabilities for cups, seals, and hoses that are components of the automotive braking system.

[1] Automotive research, NBS Tech. News Bull. 31, 139–143 (Dec. 1947) and New data on automotive combustion, NBS Tech. News Bull. 37, 113–115 (Aug. 1953).
[2] Automotive safety research expanded at NBS, NBS Tech. News Bull. 51, 246–248 (Nov. 1967).



CALIBRATION OF Phase Shifters AT RADIOFREQUENCIES

E. D. Hall adjusts the waveguide phase shifter, being calibrated, to a new setting.

THE NBS RADIO STANDARDS ENGINEERING DIVISION, Boulder, Colo., has announced a service for the calibration of variable phase shifters in WR137 (5.85–8.20 GHz) and WR62 (12.4–18.0 GHz) waveguides. A service for the calibration of variable phase shifters in WR90 waveguide has been available for several years. Also announced is the calibration of coaxial phase shifters of both the fixed and variable type over a frequency range of 100 MHz to 12.4 GHz. Formerly, calibrations were performed at 30 MHz only.

Calibrated phase shifters serve as standards for the precise measurement of phase change in a variety of systems that operate at radiofrequencies, including navigational, guidance, and fire control systems. Terrain-tracking radar systems in high-speed aircraft require very precise phase shift measurements to rely on controlled automatic-pilot operation during flight. The adjustment of phase array antennas is dependent on measurements based upon calibrated phase shifters.

Two definitions of phase shift apply for the calibrations performed by the Radio Standards Engineering Division.

Insertion phase shift is the phase change of a wave incident upon the load before and after insertion of a two-port device between the generator and load of a stable nonreflecting system.

Phase shift difference is the phase change of a wave incident upon the load from an initial to a final condition (setting) of a two-port device between the generator and load of a stable nonreflecting system.

The basic phase-shift measurement system for use with waveguides was proposed by M. Magid in 1958.[1] This system included a directional coupler and a sliding short circuit as the reference standard. The Division has made various refinements to the working standard and the calibration technique.[2] Changes in procedure, based on error analyses of the standards and calibration system,[3, 4] have been effective in decreasing uncertainties of the measurement process.

Measurement System for Calibration of Waveguide Phase Shifters

The waveguide phase-shift measurement system is a homodyne circuit employing a balanced modulator in a two-channel comparison method of operation. The basic configuration used in measuring phase-shift difference in the present calibration service is shown in the block diagram of the measurement bridge circuit. The cw microwave power source (extreme left block of the diagram) includes stabilization and frequency measurement circuits. Microwave power from this single source is divided between two bridge arms (channels) of waveguide components by an E–H tee at the output of the source. Basic portions of the lower bridge arm are a modulator and the waveguide section which permits insertion of the phase shift device under calibration.

In the present calibration system a 15-kHz modulating signal is obtained from a lock-in type amplifier which is used for suppressing the fundamental signal in the channel containing the device under calibration and for producing double sidebands. For balanced modulation, each sideband is required to be 90° out of phase with the fundamental signal of the channel containing the standard phase shifter.

The upper bridge arm contains the standard phase shifter and includes the following components: (1) directional coupler, (2) stub tuners, (3) a section of precision waveguide, and (4) a noncontacting short circuit.

Signals from the two bridge arms are combined in a crystal detector whose output is passed through a band-pass filter and then to a lock-in amplifier which serves as a null indicator. A signal from the null amplifier is available for input to a servo driven readout that is mechanically linked to a phase shift standard. Movement of phase setting of the standard during measurement can also be performed manually. An optical readout associated with the standard phase shifter provides measurement of the linear motion of the sliding short circuit to ± 50 microinches (± 1.3 μm). Ideally, the standard phase shifter relates phase shift to a measured length expressed in waveguide wavelengths,

$$\Phi = \frac{720l}{\lambda_g} \text{ degrees},$$

where l is the length of movement of the short circuit, and λg is the waveguide wavelength for the frequency of measurement, both measured in the same units.

Eldon D. Hall of the Microwave Calibration Service Section is responsible for several recent improvements in the operation and measurement method. These include: (1) reduced space requirement for the waveguide system; (2) improved operator convenience, thereby increasing the efficiency of the calibration operation; (3) improved matching technique that eliminates undesirable movements of components during calibration; and (4) a new procedure that assures correspondence between the mechanical motion of the short circuit standard and the electrical phase changes in the microwave circuit for a continuous change of 720° (required for calibration of the usual rotary-vane phase shifter to reduce measurement error to a minimum).

Measurement System for Calibration of Coaxial Phase Shifters

In contrast to the waveguide phase-shift measurement system, the coaxial system incorporates heterodyne circuitry and requires no modulation signal. At present the coaxial system is used over a frequency range of 100 MHz to 12.4 GHz. Such a system requires phase-locked operation of two rf sources that are relatively free of harmonics. The block diagram shows a system that was developed as an attenuation measurement system,[5] but is equally adaptable as a phase measurement system of considerable accuracy.

In brief, the unmodulated signal of the rf source passes through the divider as two equal signals, one to each mixer. A local oscillator provides intermediate frequency signals of 30 MHz in the bridge arrangement. One arm of the bridge contains the reference or standard phase shifter, the other arm contains the phase shifter to be measured at the insertion point. A balance of the signals in the 30-MHz channels is indicated by a detector null indicator. A waveguide below-cutoff attenuator is used in one arm of the bridge to maintain 30-MHz signals of equal amplitude in the two channels. Amplitude control is maintained with this type of attenuator without introducing changes in phase.

As an easily operated and conveniently read phase shift standard, a device commonly known as a resolver is used in one of the two 30-MHz bridge arms. In essence, the resolver output signal comes from a pickup loop that can be rotated within a circularly polarized field energized by the 30-MHz input signal. Readings taken from a dial placed on the rotating shaft give a direct indication, in electrical degrees, of phase shift in the 30-MHz bridge arm. The phase shifter to be calibrated is compared directly with the standard. The phase shift standard (resolver) is calibrated by means of a precision coaxial line designed as a trombone-type line stretcher.

Limits of Measurement Uncertainty

Phase-shift difference measurements over a range of 720° are made on variable waveguide phase shifters in three waveguide sizes: WR62 (12.4–18.0 GHz), WR90 (8.20–12.4 GHz), and WR137 (5.85–8.20 GHz). Commercially available equipment is calibrated to different limits of uncertainty because VSWR values of the ports differ considerably with frequency. For typical values of VSWR of variable waveguide phase shifters, the limits of uncertainty of measurement will vary between approximately ±0.1 and ±1 degree with matched conditions of the calibration system. For phase shifters with a VSWR of 1.1 or less, the limit of uncertainty can be less than ±0.25 degree.

Coaxial phase shifters of both the fixed and variable types are calibrated over a range of 1080° and a continuous frequency range from 100 MHz to 12.4 GHz. The total error of measurement is quite dependent upon that of mismatch error. However, with careful control of matching the phase shifter to the coaxial measurement system, the limits of uncertainty of measurement can be kept to ±0.5 degree or less.

There are basic qualities and properties that a device must have to be used as an interlaboratory standard. Phase shifters, of either the waveguide or coaxial types, should have an input VSWR less than 1.4 at each port, and variable phase shifters should have a repeatability of dial setting better than ±0.2 degree.

[1] Magid, M., Precision microwave phase shift measurements, IRE Trans. Instr. I-7, 321–331 (Dec. 1958).

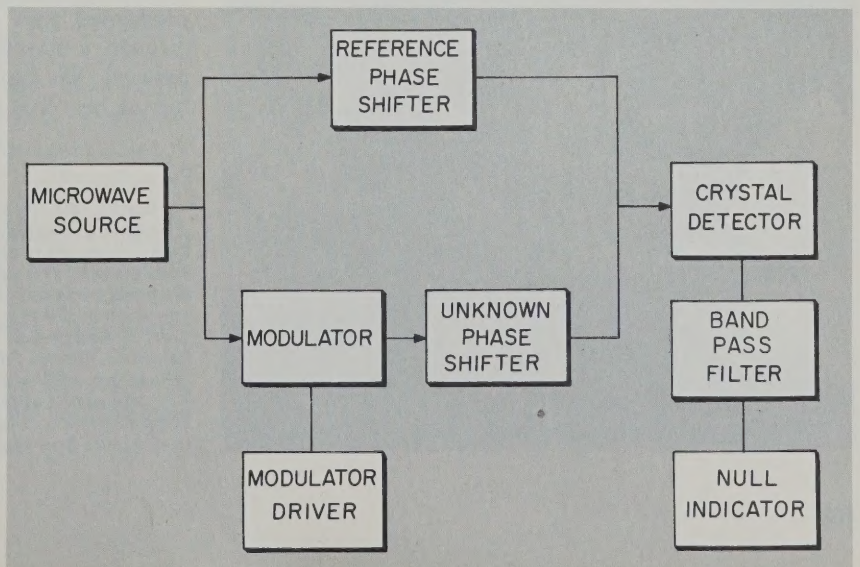
[2] Ellerbruch, D. A., Evaluation of microwave phase measurement system, J. Res. NBS 69C (Engr. and Instr.), No. 1, 55–65 (Jan.–Mar. 1965).

[3] Schafer, G. E., and Beatty, R. W., Error analysis of a standard microwave phase shifter, J. Res. NBS 64C, No. 4, 261–265 (Oct.–Dec. 1960).

[4] Schafer, G. E., Mismatch errors in microwave phase shift measurements, IRE Trans. MTT, 617–622 (Nov. 1960).

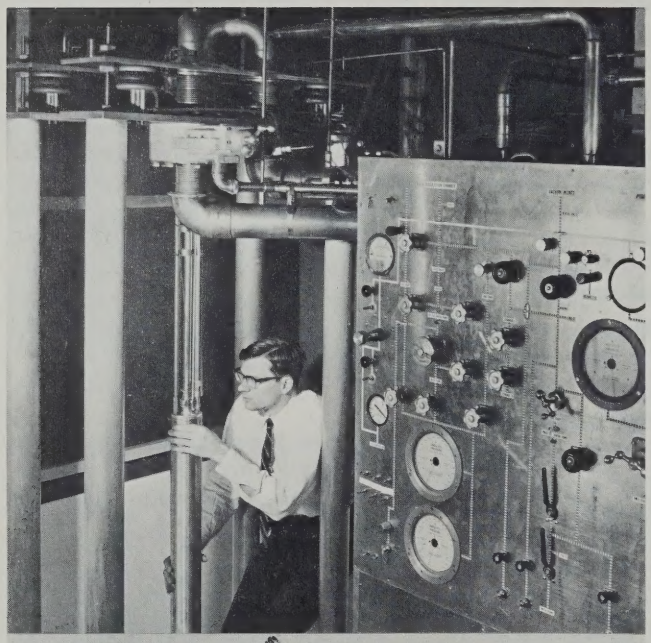
[5] Russell, D. H., An unmodulated twin-channel microwave attenuation measurement system, ISA Trans. 4, 162–169 (Apr. 1965).

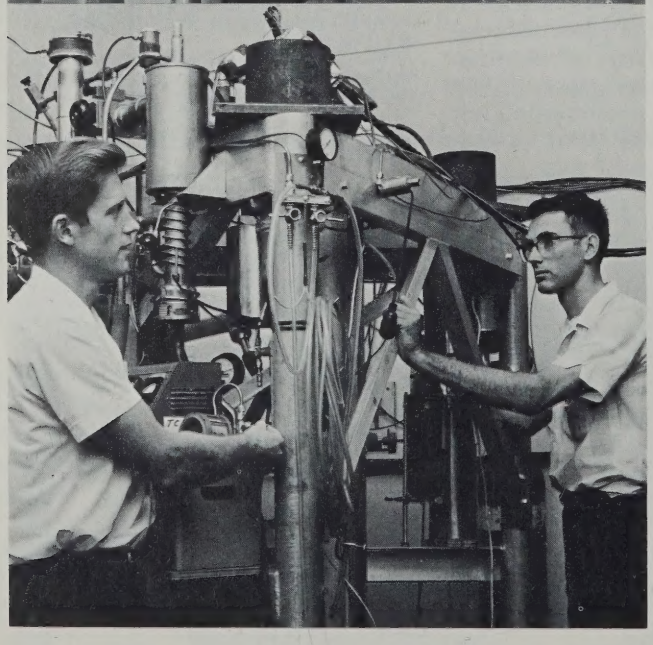
Block diagram of the basic system for the calibration of waveguide phase shifters.



DILUTION REFRIGERATORS CONSTRUCTED

Constant Temperature Maintained Near Absolute Zero





SCIENTISTS AT THE NBS INSTITUTE for Basic Standards have constructed two helium 3–helium 4 dilution refrigerators that achieve and maintain temperatures in the millikelvin region. Helium dilution refrigeration research is carried out at the NBS Gaithersburg, Md., laboratories under the direction of R. J. Soulen, Heat Division, and at the NBS laboratories in Boulder, Colo., under the direction of R. Radebaugh and J. D. Siegwarth, Cryogenics Division.

The He^3–He^4 dilution refrigerator derives its name from its utilization of two stable isotopes of helium: the rare helium 3, which has a molecular weight of 3; and the common isotope, helium 4, which has a molecular weight of 4. Dilution refrigerators were first successfully constructed in early 1966 when two researchers succeeded, independently, in maintaining continuous refrigeration below 0.1 K, using this technique.[1] Previously, such temperatures could only be reached by adiabatic demagnetization of a paramagnetic salt; however, this process is not continuous. Since the dilution refrigerator has several advantages over adiabatic demagnetization, low-temperature physicists have rapidly turned their attention to this technique for achieving supercold temperatures.

Operation

During the operation of the dilution refrigerators the following sequence of events occurs: Pure He^3 gas is condensed with a pumped He^4 bath, and then passed through a flow-limiting capillary where its pressure is reduced. The liquid He^3 is then further cooled by transferring heat first to a still and then to a heat exchanger as

Above: R. J. Soulen assembles a dilution refrigerator that is expected to maintain a constant temperature near absolute zero. It is designed to cool to its lowest temperature in less than 1 hour and provide continuous operation at this temperature for over 30 hours. Left: R. Radebaugh (left) and J. D. Siegwarth with the helium 3– helium 4 dilution refrigerator that they constructed for use in a wide variety of low-temperature experiments. The cold region of the refrigerator is inside metal-shielded glass dewars (center). The cryostat is mounted on air springs to eliminate heat leak due to vibrations.

it flows to a mixing chamber, where the refrigeration takes place. Cooling takes place in the mixer when the He^3 crosses a phase boundary and is diluted by He^4. The explanation for the cooling is quite analogous to that for the vaporization of a liquid.

Although both He^3 and He^4 are present in the mixing chamber, they do not form a homogeneous solution, since below about 0.8 K such a mixture separates into two phases. Therefore, in the mixer, the pure He^3 floats on top of, and is in equilibrium with, a He^4 rich phase that contains approximately 6.4 percent of He^3.

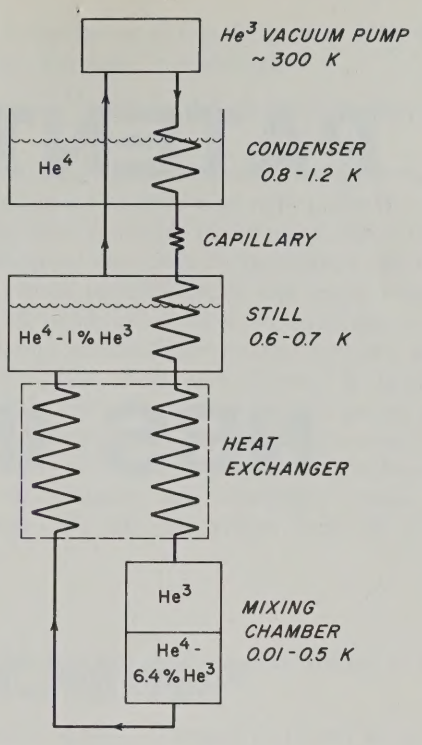
This dilute solution communicates with a He^4–1 percent He^3 solution in the still by way of the return line in the heat exchanger. In the still, He^3 is preferentially removed from the dilute solution, since the vapor above the boiling liquid is nearly pure He^3. This He^3 gas is then compressed at room temperature and returned to the condenser to be recirculated in the system.

As He^3 is removed from the dilute solution in the still, He^3 diffuses from the He^3 rich phase in the mixer across the phase boundary, into the dilute solution. The He^3 in the dilute solution continues to diffuse through the He^4 in travelling from the mixer, through the heat exchanger, and finally to the still. As the He^3 passes through one side of the heat exchanger, which is the most crucial component for achieving millidegree temperatures, it cools the incoming pure He^3 liquid in the other side of the heat exchanger.

At the Boulder laboratories, Drs. Radebaugh and Siegwarth have designed and constructed a dilution refrigerator that has the capability of continuous operation for up to 3 days, at temperatures in the millidegree region. This refrigerator, which is still being tested, has a refrigeration rate of approximately $2.5 \times 10^{-3}\ T^2$ W K^{-2} for temperatures between 0.030 and 0.5 K. The refrigeration rate falls rapidly to zero near the lowest operating temperature, which to date is 0.020 K. However, it is expected that by varying parameters in the system, the refrigerator can be operated at a lower limit in the future.

Applications

This refrigerator will be used for a wide variety of low-temperature experiments by scientists in the Cryogenics Division. Among the proposed experiments are studies of methods to improve the dilution refrigerator. Such studies will include research on various types of heat exchangers, as well as thermodynamic and transport properties of He^3–He^4 solutions. This research is a continuation of work conducted by Dr. Radebaugh prior to the construction of the refrigerator, and which included a thermodynamic analysis of dilution refrigerators with a compilation of a complete and consistent set of data for thermodynamic properties of liquid He^3–He^4 solutions between 0 and 1.5 K.[2] In addition, the refrigerator will be used for the study and development of the Josephson junction noise thermometer and for investigations of the properties of dilute alloys.



Flow diagram for the He^3–He^4 dilution refrigerators. Cooling occurs when He^3 (pure) diffuses through the He^3–He^4 solution in the mixer to the still; the change of phase from pure He^3 to a dilute solution causes heat absorption.

At the Gaithersburg laboratories, Dr. Soulen has constructed a prototype dilution refrigerator, which circulates about 2×10^{-5} mole per second of He^3 gas, and which operates down to 0.028 K for periods up to 5 hours. Susceptibility measurements on cerium magnesium nitrate and nuclear quadrupole resonance in cerium chloride were carried out to 0.050 K before it was decided to make some revisions, including an inner pumped He^4 bath. In the future, NBS will use the apparatus for short (less than 10 hours) general-purpose experiments.

Another dilution refrigerator is in the final stages of construction in the Cryogenic Physics Section. This model will have twice the circulation and cooling rate of the prototype. The new apparatus is designed to cool from 1 K to its lowest temperature in less than 1 hour, and is expected to provide continuous operation at this lowest temperature for times in excess of 30 hours. Experiments on the low temperature properties of cerium magnesium nitrate and alloys of zinc-manganese are planned initially for this apparatus.

[1] Hall, H. E., Ford, P. J., and Thompson, K., Cryogenics **6**, 80 (1966); also Neaganov, B. S., Borisov, N., and Liburg, M., Soviet Physics JETP **23**, 959 (1966).

[2] Radebaugh, R., Thermodynamic Properties of He^3–He^4 Solutions with Applications to the He^3–He^4 Dilution Refrigerator, NBS Tech. Note 362 (Dec. 29, 1967).

PATENTS GRANTED ON NBS INVENTIONS

Royalty-free, Nonexclusive Licenses Available

The research and development performed at the Bureau often results in inventions that have potential commercial use. To ensure that these inventions are made available to the public without the payment of patent royalties, NBS—or the Government agency that sponsored the NBS research leading to an invention——files patent applications on the inventions, and grants royalty-free, nonexclusive licenses under the resulting patents to qualified manufacturers.

Patents recently awarded to NBS inventors are briefly described below. Manufacturers interested in obtaining a license under one or more of the patents should address a request to the Office of the General Counsel, Department of Commerce, Washington, D.C. 20230, unless a different administering office is indicated.

Method of Storing Oxygen

R. A. Ruehrwein and J. S. Hashman, U.S. Patent No. 3,378,351, April 16, 1968.

As described in this patent, oxygen-users can safely store oxygen *as a solid complex compound* at normal pressure and at temperatures below 86 K. The compound is prepared by blending oxygen gas with another gaseous material, for example, water vapor, nitrogen dioxide, ethylene, or isobutylene, and subjecting the blend to extreme low temperatures of about 4.2 K. A solidified product is formed which is a complex of molecular oxygen and another compound. The solidified product is then warmed to 66–77 K to allow the uncomplexed oxygen to be pumped from the solidification zone. The remaining solid complexed material is much more stable than pure solidified oxygen and may be stored indefinitely at temperatures up to 86 K. The oxygen is obtained by warming the material to a point at which oxygen gas is evolved.

Administering office: Office of the Judge Advocate General, Patent Division, Department of the Army, Washington, D.C. 20315.

Synthesis of Perfluoroparacresol, Perfluoroparathiocresols, and Polyoxyperfluorobenzylene

L. A. Wall and J. M. Antonucci, U.S. Patent No. 3,394,190, July 23, 1968.

There is great interest in the development of thermally stable polymers. For wide commercial application, a thermally stable polymer should also possess high tensile strength, resistance to strong chemicals, and thermoplastic and elastomeric character. This patent describes a method of preparing perfluoroaromatic monomers from which polymers having the above properties may be prepared.

Administering office: Patent Counsel, Department of the Navy, Washington, D.C. 20360.

Information Storage and Category Selector

S. Henig and E. C. Palasky, U.S. Patent No. 3,397,392, August 13, 1968.

This patent describes a computer-controlled machine for rapidly sorting postal letters into a number of direct destination categories requiring no further sorting, or into secondary destination categories requiring further sorting en route. The letters to be sorted are temporarily stored in slots, and the destination and slot information are entered into the computer. The computer tallies the number of letters in each category, and in groups of related categories. It compares the tally for a category (or group of related categories) with the category's threshold, and simultaneously determines which category has the largest tally. If the tally exceeds the threshold, the computer actuates the storage slots to unload the letters. If the tally does not exceed the threshold, the computer unloads the category that has the largest tally. The program repeats the process providing optimum reduction in the inventory of stored letters.

Refractometer That Measures the Difference in Refractive Indices of a Gas at Two Frequencies

M. C. Thompson, Jr., and M. J. Vetter, U.S. Patent No. 3,400,330, September 3, 1968.

The instrument described in this patent can be used by chemists, physicists, or meteorologists to measure the dispersion of a gas sample The sample is introduced into a multimode microwave cavity which is excited by a pair of swept, harmonically related signals. The dispersion of the sample causes two harmonically related modes in the cavity to resonate at different times in the sweep cycle. Thus, by detecting the resonance peaks and measuring the phase difference between them, the dispersion of the sample can readily and precisely be determined.

High Vacuum Baffle Using Cooled, Chevron-Shaped Members

J. G. Carlson, U.S. Patent No. 3,410,100, November 12, 1968.

Cooled baffles are widely used in conjunction with high-vacuum diffusion pumps to condense the pump-fluid vapors and thereby prevent the vapors from entering the space being evacuated. The cooled baffle described in this patent is easily fabricated from a series of chevron-shaped members of rotation, and is readily assembled (and disassembled) by nesting the members and inserting a pair of coolant tubes through alined apertures in the members.

Variable Impedance Coaxial Device with Relative Rotation Between Conductors

J. E. Cruz, U.S. Patent No. 3,417,350, December 17, 1968.

In transmitting radio frequency energy over coaxial lines, it often is desirable to provide in the line a section of coaxial line of variable impedence to allow for impedance matching. The variable impedance line described in this patent includes inner and outer coaxial conductors of *noncircular* cross sections, the outer conductor being mounted for coaxial rotation about the inner conductor. This arrangement is mechanically simpler than the prior devices (which use eccentrically rotated conductors), and is electrically superior to the prior devices as it readily propagates the desired TEM mode, and because the impedance versus angular orientation of the conductors can be computed precisely.

Distance Measuring Instrument Using a Pair of Modulated Light Waves

P. L. Bender and J. C. Owens, U.S. Patent No. 3,424,531, January 28, 1969.

In this instrument, light at two wavelengths is modulated at a radio frequency and transmitted over a path whose length is to be measured. The modulation frequency is varied until the path length for one of the wavelengths of light is an integral number of modulation wavelengths. The path length for the other wavelength of light is then adjusted a small amount until the adjusted path length is also an integral number of modulation wavelengths. From these two measurements of the path length with two wavelengths of lights, the true path length—corrected for the integrated refractive index of the path—can readily be computed.

High Temperature Substitution Reactions of Hexafluorobenzene

L. A. Wall and J. M. Antonucci, U.S. Patent No. 3,429,935, February 25, 1969.

This patent describes a simple high-temperature method of replacing one or more of the aromatic fluorines in hexafluorobenzene to provide potential monomers for the synthesis of new, thermally stable polymers (elastomers). In the method, hexafluorobenzene and a halogen are reacted in a stream of nitrogen in a hot tube containing glass wool, carbon pellets, nickel turnings, or platinum gauze, at a temperature of 300–1000 °C.

Administering office: Patent Counsel, Department of the Navy, Washington, D.C. 20360.

THREE NEW LABORATORIES ADDED TO COMPLEX

THREE ADDITIONAL SPECIAL PURPOSE LABORATORIES in the Bureau's $120 million complex are now being occupied. With completion of the Industrial Laboratory, the Aggregate Processing Materials Building, and the Hazards Laboratory, 19 of the 20 major buildings planned for the Gaithersburg, Md., campus have been completed.[1] The other, the Fluid Mechanics Building, is now under construction. When completed it will mark the end of the Bureau's construction program begun in 1961.

Each of the three buildings incorporates features especially designed for the research carried out in that building.

Industrial Laboratory

The Industrial Laboratory is devoted to research activities in the industrial technologies related to glass, ceramics, crystals, and metallurgy, and also to plastics, papers, and textiles. The groups are accommodated in two high-ceilinged areas with smaller laboratories adjacent.

Apparatus necessary for the sample preparation of glass, ceramics, crystals, and metals may be found in the Laboratory, together with other specialized equipment. Glass melting furnaces are available to produce special glass melts up to 20 liters. High temperature facilities exist for the preparation of polycrystalline ceramic specimens in any required shape and size with appropriate furnace capabilities.

High temperature facilities will also be used for the preparation of single crystals. A recent acquisition is a crystal growing furnace capable of operating in any of the three modes of crystal pulling (Czochralski, Bridgman, and zone refining). The furnace is capable of crystal growth by these three well-known methods in environments ranging from vacuum to 300 psi (2×10^6 N/m^2) in the usual atmospheres or any desired gaseous phase. Equipment also exists for the production of single crystals by growth from the vapor phase.

The portion of the building assigned to metallurgy houses a modern and well balanced metals-processing facility. In this facility pure specimens with desired characteristics are produced for use in other Bureau research. For shaping metals, there are rolling mills, swaging machines, and a compacting press. For melting, there are a variety of furnaces, including an air induction furnace, several vacuum and atmosphere annealing furnaces, a levitation melting unit, and an arc furnace. In addition, there is electron-beam melting, zone-refining, and evaporation equipment along with several varieties of crystal-growing devices.

Included in the plastics, paper, and textiles research technology facilities are laboratories for research and technical standardization programs, an experimental paper mill, and a textile-plastics technology laboratory. The laboratories include facilities for performing chemical, physical, colorimetric, and engineering studies on paper, plastics, and textiles, as well as instrumentation and chromatographic investigations.

The Bureau's paper mill features a new research Fourdrinier paper machine that incorporates some of the most modern and highly specialized equipment in the field. The mill is equipped with new stock preparation equipment and finishing equipment.

A paper-coating laboratory will include a coating line and auxiliary laboratory facilities for the investigation of coating formulations.

In the textile and plastics laboratories, pilot-scale equipment is used to investigate the chemistry and technology of textile dyeing and finishing and to study plastic materials. Such equipment includes a tenter frame, dispersion mill, padder, beck and jig, and related laboratory equipment for the formulation and preparation of materials of importance to the program.

Aggregate Processing Building

The Aggregate Processing Building is designed for the batching, blending, processing, and storage of fine and coarse aggregates used in experimental concrete programs. Within this building concrete and cement standard reference materials are prepared for distribution to test laboratories throughout the country. Accurate control of the size fractions of aggregates is often required for concrete used in research programs. Such highly uniform materials will enable other laboratories to test the accuracy of their operations, to compare results with each other, and to identify areas in which test methods are inadequate or need modification.

One of the building's unique features is a group of 16 concrete bins, which constitutes one wall. The roof over these bins is at ground level, permitting trucks to dump aggregates

into the bins. With the exception of two bins for wet sand, the aggregates of each bin can be dried in place by a forced-air heater.

Processing equipment includes a small conical blender, a 20-cubic-foot twin-shell blender, and crushing, grinding, and screening equipment. Future plans call for a 75-cubic-foot blender.

Hazards Laboratory

Located at the far end of the Bureau campus, the Hazards Laboratory supports two main research activities—distillation experiments and high temperature experiments. In this building facilities are available for research that has some risk of hazard, such as work with chemicals having offensive or toxic vapors, fire, or corrosiveness, or in situations where explosion is a suspected possibility.

The building incorporates many advanced safety features. In the event of a minor explosion, the outer walls of the building are designed to collapse; the inner laboratory walls are one-foot-thick reinforced concrete. Doors from the laboratories do not open directly into the main corridor, but, rather, into a small hallway off the corridor. All electrical outlets are shielded to prevent sparking, and electric lights are protected with heavy glass and metal guards. The building's air-conditioning system continually circulates fresh air to eliminate any toxic fumes released during experimentation.

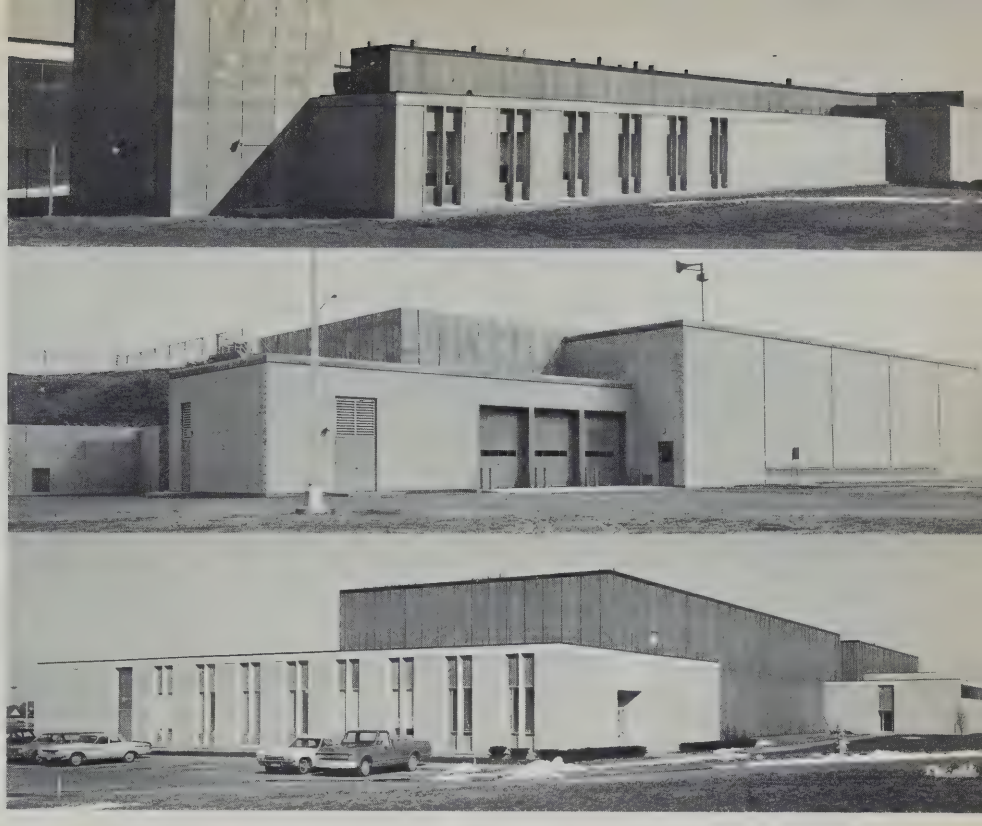
In the Hazards Laboratory, precision laboratory distillation is used to prepare highly purified sample specimens. Distillation from quartz apparatus is being used in the purification of mineral acids and is being readied for use in the purification of chemical reagents. Specimens under study most often are corrosive liquids such as hydrochloric and nitric acid, which then are collected and quickly frozen by liquid nitrogen. Special reagents are stored in a materials cold bank where they are reserved for use by chemists working at the limits of chemical measurement, specifically studies with trace impurities.

An adjacent facility within the Hazards Laboratory, the hydrogenation laboratory, is reserved for carrying out hydrogenation reactions at high pressures up to 100 psi (7×10^5 N/m^2).

Much of the remaining portion of the building is assigned to high temperature experiments where the properties of materials are measured under dynamic conditions. Such studies depend on both high currents and high voltages ranging from 1000–100 000 A and 100 000 V, respectively. Materials of primary interest at this time are metallic elements and alloys with high melting points (above 2000 K).

A typical experiment lasts only a fraction of a second. During this time the specimen is heated to several thousand degrees and all the pertinent quantities are measured with millisecond resolution. A unique device that is employed in these studies is a pyrometer capable of making temperature measurements in 1/1000 second.

Future activities may incorporate high pressure experiments with pressures up to 100 000 atmospheres (1.013×10^{10} N/m^2). These activities will be under both static and dynamic conditions using high pressure pulse and shock techniques.



Above: The Hazards Laboratory supports research having some degree of risk, such as high temperature experiments. Offices (front) are separated from the laboratories (rear) by a labyrinth of hallways.
Center: The Aggregate Processing Building was designed for the batching, blending, processing, and storage of aggregates. At the rear wall, the roof is at ground level, permitting trucks to dump aggregates into concrete bins.
Bottom: The Industrial Laboratory is devoted to research activities in glass, ceramics, crystals, metallurgy, plastics, papers, and textiles.

[1] The new NBS laboratory complex, NBS Tech. News Bull. 50, No. 11, 200–205 (Nov. 1966).

NEWS

The NSRDS was established to make critically evaluated data in the physical sciences available to science and technology on a national basis. The NSRDS is administered and coordinated by the NBS Office of Standard Reference Data.

Thermodynamic Properties of Argon

NSRDS–NBS 27, *Thermodynamic Properties of Argon From Triple Point to 300 K at Pressures to 1000 Atmospheres*[1] ($1.25), by A. L. Gosman, R. D. McCarty, and J. G. Hust, has recently been published to meet the increased technical and scientific interest in pure argon. This is evidenced by a demand for pure argon which has increased more than sixfold in the last 12 years. United States production has increased from less than 200 million cubic feet in 1953 to over 1 billion cubic feet in 1965, with about 80 percent of the element being shipped in liquid form. Scientific interest in argon has arisen because of its characteristically "ideal" structural makeup. Argon is monatomic and the relatively uncomplicated interatomic forces can be approximated by spherically symmetric, nonpolar models. Further, the quantum effects on argon are relatively small. For these reasons, argon permits a more direct classical investigation and experimental verification of theoretical model predictions.

In view of the increased activity in cryogenic engineering and physics, the need for a set of consistent thermodynamic properties, over a relatively large region of the thermodynamic surface, was apparent. The NBS Cryogenics Laboratory (Boulder, Colo.) undertook a program of making a critical analysis of the thermodynamic properties of argon in the cryogenic temperature range, including the low-temperature, high-density region.

In recent years, much of the technical design and synthesis has been done with the aid of high speed digital computers. Thus the need for an analytical equation of state has become quite significant for the use of tables and charts of thermodynamic properties. Many equations of state have been proposed in the literature, each with its own strengths and weaknesses. Some of these equations represented the data in certain regions of the thermodynamic surface, but were quite inadequate in other regions of the surface. Therefore, the need was established for a single equation of state which could accurately and consistently represent the data for both the liquid and vapor phases with a consistent transition from the low-temperature, high-density region to the low-density region.

In the case of argon, assessing the general overall adequacy of an equation of state in terms of deviations from the experimental PVT surface is difficult. Because of the inconsistency in some of the overlapping experimental data sources, there is no single experimental PVT surface which can be used as a reference. The significance of the deviation is highly dependent upon the variable chosen for the comparison and the specific region of the thermodynamic surface that is being studied. In certain regions of the surface, large pressure deviations are caused by small density errors, while in other regions the reverse is true.

As part of the critical analysis going into this volume, the development of a vapor pressure equation that would accurately represent the experimental vapor pressure data was deemed necessary. From the triple point to the critical point, this vapor pressure equation could then be used, in conjunction with the equation of state, to calculate some of the derived thermodynamic properties such as enthalpy and entropy.

A comprehensive search of the literature resulted in a bibliography of about 425 references. From this literature search, the most appropriate PVT data, vapor pressure data, coexistence density data, and fixed point data were selected for consideration and evaluation. In addition, virial coefficient data, Joule-Thomson data, specific heat data, and information on equations of state were acquired and considered.

NSRDS–NBS 27 presents tabular values of density, internal energy, and enthalpy, and entropy of liquid and gaseous argon. For temperatures from 83.8 to 300 K, and pressures from 0.01 to 1000 atmospheres, diagrams of specific heats, compressibility factor, and entropy are included. The properties presented are calculated from an equation of state which was fitted to experimental PVT data from the world literature. Extensive comparisons are

made of the equations of state, and the experimental data and deviation plots are presented. The second virial coefficient and Joule-Thomson/inversion curve were also calculated and comparisons made with values from other sources. A vapor pressure equation that covers the range from triple point to 300 K is also given.

While an abundance of thermodynamic data for argon is available in the literature, only quite recently have investigators begun to appreciate the inherent difficulties associated in obtaining good data in the region of the critical point. New techniques are being utilized to investigate critical point behavior, and older techniques are being updated to include the high precision which is necessary to describe this region. Theoretical studies are being made to try to understand the behavior of this interesting region, but much more experimental and theoretical work has yet to be done before a complete and definitive description of this critical region can be obtained.

The compilation was supported by the Office of Advanced Research and Technology of the National Aeronautics and Space Administration. The literature search was part of the activity of the NBS Cryogenic Data Center, Boulder, Colo.

Evaluated Infrared Spectra

The Coblentz Society has announced the availability of 1000 high quality infrared spectra. Although technically a continuation of the Coblentz Spectra series, the spectra have been evaluated by expert spectroscopists and selected to meet criteria established by the Coblentz Society for the National Standard Reference Data Program. Included in the current issue are 500 pharmaceuticals, 100 organosilicon compounds, and 400 general organic structures.

These spectra have been contributed by various infrared laboratories, and each must meet the following criteria to be included:

(1) It must be a better quality spectrum than any previously published for this compound, or be a spectrum *not* previously published; and

(2) Each spectrum must have been critically evaluated by competent spectroscopists as to its technical quality. (It must meet or exceed the criteria for Class III reference spectra, as established by the Coblentz Society [2] and it must be consistent with the assigned chemical structure.)

These spectra are to be issued in blocks of 1000. The first 1000 spectra are now ready for publication, and will be available by early summer 1969. They may be ordered from Sadtler Research Laboratories, 3316 Spring Garden St., Philadelphia, Pa. 19104, which is serving as the publisher. The price is $265 per 1000 spectra, including loose-leaf binders. One spectrum is printed to a page and includes approved chemical name, structural and molecular formula, state, melting or boiling point, and notation as to how the spectrum was obtained.

USA Standard Codes for Textual Data

The USA Standards Institute Subcommittee X3.2, Codes and Input/Output, has established an ad hoc task group to consider the development of standard codes for representing text in forms suitable for text editing, text processing, linguistic processing, information retrieval, and automated typesetting. It has been designated X3.2G, Codes for Textual Data.

The work of this task group will be one of the activities in the continuing development of codes derived from the USA Standard Code for Information Interchange (USASCII), USA Standard, X3.4–1968. These activities fall under the direction of USASI Sectional Committee X3, Computers and Information Processing, and are sponsored by the Business Equipment Manufacturers Assoc., 235 East 42d St., New York, N.Y. 10017.

The term "textual data" is taken to mean more than simple plain language or linear test. Consideration is being given to representing various notational devices used in documents intended for human interpretation. Examples are superscripts, subscripts, tables, logical flow diagrams, schematic diagrams of electronics circuits, and diagrams representing chemical structures.

The initial meetings of X3.2G will be primarily concerned with organizational matters and the specification of objectives and work programs. A major agenda item will be the identification and selection of representative documents that can be assembled into a background source book. This source book will serve as the minimum set of examples for use by individuals and working groups within X3.2G. A second major agenda item will be the identification of people, not now participating in X3.2, who may be able to contribute as members of X3.2G.

In its source book, X3.2G will need documents exemplifying various categories of textual data for which standard codes are desired. From these, bench mark test pages will be prepared for use in studying codes and the code dependent features of text processing systems. X3.2G will also need parts of user manuals for existing text processing systems that are augmented by guidelines for programers showing how and at what interfaces code dependence affects the important characteristics of the systems. Analyses of graphic character set requirements including the need for special symbols will be sought from workers in various disciplines. X3.2G hopes to have several examples showing adjustments of requirements to the practical restraints imposed by USASCII and USASCII-like codes. X3.2G will seek to secure the participation of the kind of people competent to prepare material for the source book.

People who may be concerned with the technical aspects of the X3.2G work are urged to write: Dr. B. C. Duncan, Chairman, X3.2G; Rm. B154 Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234. People desiring general information and lists of USA standards

may obtain these from: United States of America Standards Institute, 10 East 40th St., New York, N.Y. 10016.

British Scientific and Technical Information Activities

The Office for Scientific and Technical Information (OSTI), Department of Education and Science of the United Kingdom, has issued a third edition of "Data Activities in Britain." This is a list containing 100 entries of physical data compilation activities in the U.K. Free copies are available from Office for Scientific and Technical Information, Elizabeth House, 39 York Rd., London, S.E. 1, U.K.

Among OSTI's activities is support for work equivalent to that of the Office of Standard Reference Data. It has recently awarded a grant to Queen's University, Belfast, Northern Ireland, to set up an interactive data system on atomic and molecular physics. The work is under the supervision of F. J. Smith, Department of Applied Mathematics. Its aims are to collect numerical data on atomic physics, such as intermolecular potentials, computed atomic wave functions, cross sections, and rate coefficients, as well as to study methods of storing such data efficiently so as to provide a data bank for a system that will allow on-line retrieval.

Another recent OSTI development is the Documentation Processing Center (DPC) whose main objective is to enable computers to play a more effective part in the scientific and technical systems of the U.K. DPC seeks to perform this objective in the following ways:

(a) By providing professional support for OSTI computer-based projects through consultative services, project evaluation, systems design, and technical liaison; DPC staff cooperate with OSTI and grant-aided staff in all stages of such projects.

(b) By providing those engaged in experimental information projects with access to a wide range of computing and allied facilities, which can be applied more economically and efficiently by (or through) a specialized center than by general service bureaus or by the institutions responsible for the projects. These facilities include computing capacity for handling large nonnumerical data banks, standardized software, and special-purpose equipment for data collection or presentation, such as optical character-reading devices, computer-typesetting equipment, and graphical input or display consoles.

(c) By undertaking research on computing aspects of the handling of scientific and technical information—particularly on the design, development and evaluation of computer programs, on processing operations, and on graphical input and display; by coordinating any such research as is included in OSTI-supported projects; and by cooperating with other institutions at home and abroad that are conducting research on these or allied lines.

(d) By contributing nationally and internationally to the development and acceptance of standards in computer-based information services and so providing greater compatibility between the programs and materials produced by different projects; these standards cover, for example, formats for computer systems, program documentation and information exchange.

High Temperature Chemistry and Physics of Materials

The National Bureau of Standards has undertaken to publish a quarterly current awareness bibliography that has been issued since 1958 under the auspices of the International Union of Pure and Applied Chemistry (IUPAC). The decision to publish a specialized bibliography in the field of high-temperature chemistry was made in 1957 by the Commission on High Temperatures and Refractories of IUPAC, in recognition of the growing importance of the field for science and technology and the fact that its literature was so widely scattered. The first bibliography covered the literature of the last quarter of 1957, and the series has since continued, without interruption, four times a year. It is planned to carry on the series indefinitely; however, it will be published by NBS instead of by IUPAC, although it retains IUPAC sponsorship.

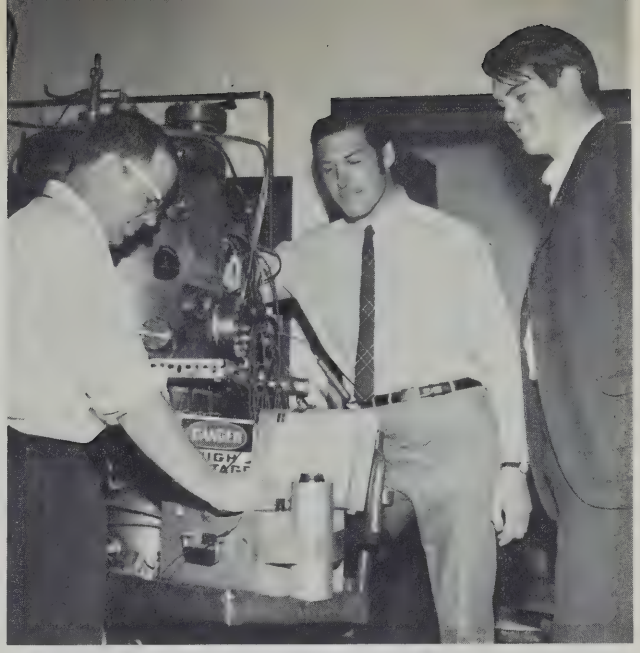
In this issue, the items are classified into Part I, Solids and Liquids, and Part II, Gases. Part I is subdivided into: Devices for achieving temperatures above 1500 °C; devices for measuring and controlling temperatures above 1500 °C; devices for physical measurements at temperatures above 1000 °C; thermodynamic properties, at temperatures below 1000 °C, of materials which melt above 1500 °C; properties, at temperatures above 1000 °C, of materials which melt above 1500 °C; properties, at temperatures above 1000 °C, of materials which melt below 1500 °C; phase equilibria above 1000 °C; reactions at temperatures above 1000 °C; and books. Part II is subdivided into: Spectroscopy of interest to high temperature chemistry; and reactions between gases and condensed phases.

The bibliography is compiled by an international Working Group on Bibliographies (attached to the Commission on High Temperatures and Refractories) of about 15 scientists. These scientists scan their national literatures, abstract the relevant references, and forward them to NBS where they are collected, edited, and published. The latest installment is published as NBS Special Publication 315, *Bibliography on High Temperature Chemistry and Physics of Materials—October, November, December 1968* [1] (70 cents). It is edited by J. J. Diamond of the NBS Institute for Materials Research.

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

[2] Specifications for Evaluation of Infrared Reference Spectra, Anal. Chem. 38, No. 9, 27A–38A (Aug. 1966). Reprints are available from the NBS Office of Standard Reference Data, Rm. A521, Admin. Bldg, National Bureau of Standards, Washington, D.C. 20234.

Josephson Effect Shows Promise in Radiofrequency Range



L. O. Mullen (left) monitors temperature during fabrication of a thin-film Josephson junction while R. A. Kamper (center) and D. B. Sullivan observe.

MANY OF THE UNIQUE PROPERTIES of superconductors suggest future utilization in technological applications. One of these properties with a high potential for use in electronic devices is the Josephson effect. Recently, scientists in the NBS Cryogenics Division (Boulder, Colo.) have developed techniques in the use of the Josephson effect in the radiofrequency range that should aid significantly in the application of superconductivity to electronics. This work was done by R. A. Kamper, L. O. Mullen, and D. B. Sullivan.

The Josephson effect occurs at a weak electrical contact between two superconductors that are separated by a thin barrier. When a small steady voltage is applied to this contact, it oscillates at a frequency proportional to the voltage (about 484 megahertz per microvolt). This Josephson oscillator offers the promise of a new generation of very sensitive devices for such measurements as voltage, temperature, and atomic spectra.

For a Josephson oscillator to work, the degree of electrical contact must be closely controlled, and the permissible range becomes narrower as the frequency is reduced. The first observation of Josephson oscillation,[1] in 1965, was achieved at a microwave freqency of about 10 GHz using junctions consisting of narrow strips of superconducting thin films, on suitable substrates, separated by very thin oxide layers. Subsequently, in 1966, the effect was observed at about 30 MHz, using an adjustable point contact[2] to avoid the difficulties of fabricating permanent junctions. Clearly, a point contact that must be adjusted every time an instrument is operated is undesirable.

The NBS investigators demonstrated the feasibility of permanent instruments, based on Josephson oscillation in the radiofrequency range, by observing the oscillation of a thin film Josephson junction at 38 MHz—the first observation of Josephson oscillation in this frequency range using thin films. The junction was formed between overlapping strips of thin films of niobium and lead, separated by an oxide layer, on a sapphire substrate.

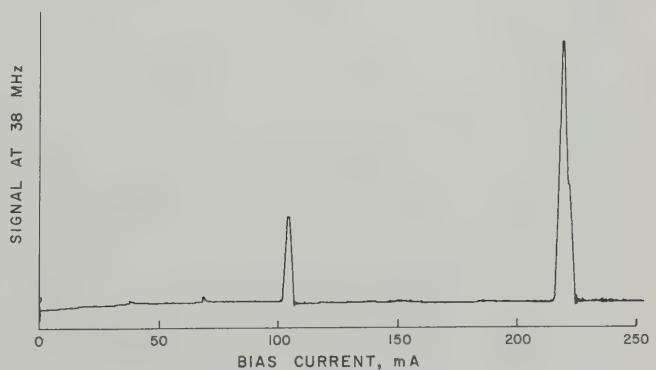
The technique for fabricating the junction consists, essentially, of the following steps. The niobium film is evaporated onto the sapphire substrate at +400 °C in a high vacuum. It is then cooled to −200 °C with liquid nitrogen and exposed to a glow discharge in pure oxygen gas at a low pressure. Then it is warmed to an intermediate temperature (below ambient) in a high vacuum, cooled again to −200 °C, and the lead film evaporated on top. This technique has resulted in a high yield of excellent tunnel junctions, with low background currents and long-term stability, that promise future utilization in such instruments as low-level null detectors, low-level voltmeters, voltage standards, magnetometers, current standards, radiofrequency spectrometers, microwave amplifiers and mixers, infrared detectors, computers, and millidegree noise thermometers.

The delicate adjustment required to bring the junction into the oscillating state was accomplished by applying a small magnetic field, with a flux density of the order of 10^{-4} tesla. In a permanent instrument, this would be supplied by passing a preset current through a small coil placed near the junction.

Further work to improve the quality control during fabrication of junctions and to improve the lifetime of these devices is in progress.

[1] Yanson, I. K., Sristunov, V. M., and Dmitrenki, I. M., Zh. Eksper. Teor. Fiz. (U.S.S.R.) **48**, 976 (1965). Transl: Soviet Physics—JETP **21**, 650 (1965). Also, Langenberg, D. N., Scalapino, D. J., Taylor, B. N., and Eck, R. E., Phys. Rev. Letters **15**, 294 (1965).

[2] Zimmerman J. E., Cowan, J. A., and Silver, A. H., Appl. Phys. Letters **9**, 353 (1966).



This is the first observation of thin-film Josephson oscillation at 38 MHz and may facilitate applications of superconductivity to electronics.

NEW OUTDOOR WEATHERING SITES ESTABLISHED

THE BUREAU RECENTLY COMPLETED establishment of six new outdoor materials-testing sites. The sites were selected to provide diverse prevailing weather conditions. They will be used for a wide variety of outdoor performance studies on metals, paints, plastics, roofing materials, porcelain enamels, and other materials.

The sites are located at the following facilities: NBS, Gaithersburg, Md.; Fort Holabird, Baltimore, Md.; U.S. Naval Station, Roosevelt Roads, P.R.; Nellis Air Force Base, Las Vegas, Nev.; Fort Lewis, Tacoma, Wash.; and Fort Greely, Fairbanks, Alaska.

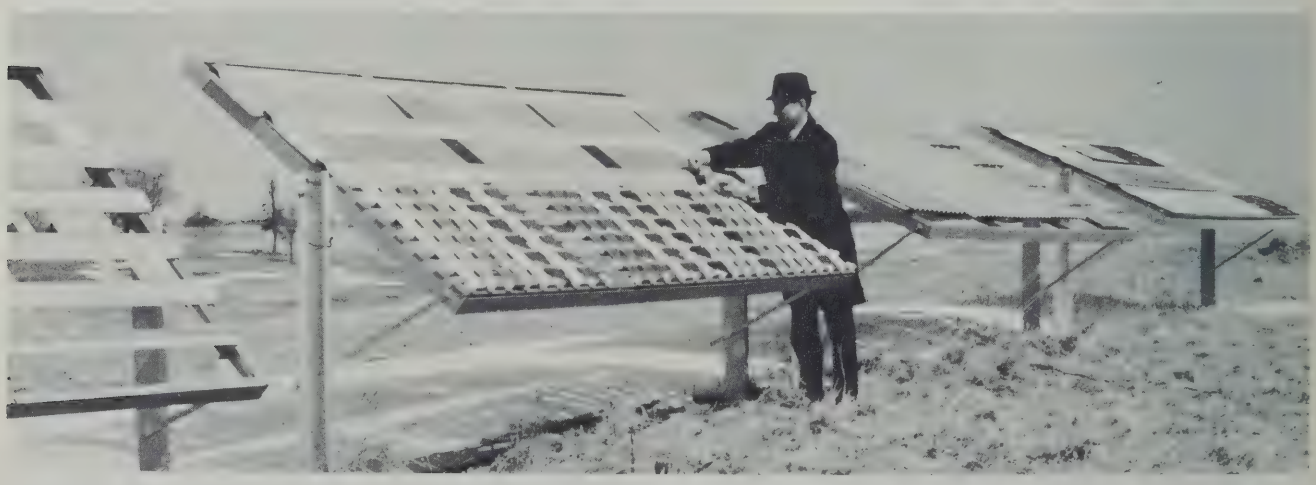
The last five of these six sites are located on military installations through the courtesy and cooperation of the Army, Navy, and Air Force. The three military services granted permission for NBS to enclose areas of approximately 100 × 200 feet and to erect permanent racks for holding specimens. It is expected that eventually each of these sites will be instrumented to record the various parameters of weather and atmospheric pollution that are found to be aggressive toward building materials.

Much valuable information is expected to result from exposing materials in these different environments. In one study, for example, the effects of air pollution on building materials is being examined. Other studies underway or planned will evaluate the weathering characteristics of aluminized steel, the effects of weather on roofing products, the spalling resistance of porcelain enamels, the color stability of plastics, and the durability of paints.

This outdoor weathering site at Nellis Air Force Base, Las Vegas, Nev., provides a desert environment for exposure tests of materials.

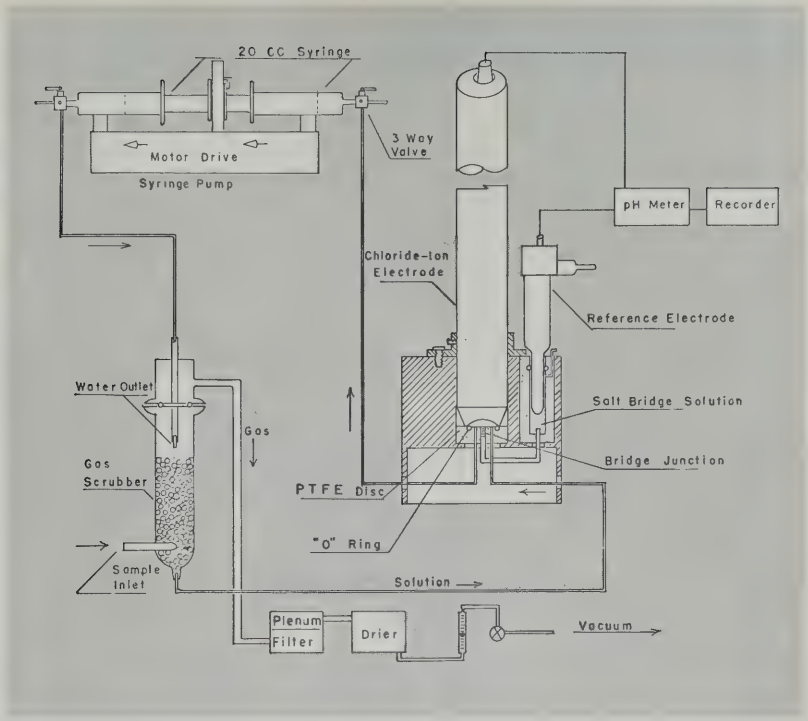
In some of the studies, sufficient specimens will be originally exposed to allow for up to 20 years of testing.

The sites will also provide data for comparison with data from artificial weathering devices in the laboratory. It is hoped that these data will lead to improved artificial weathering devices and new test methods that will be able to simulate outdoor conditions in reduced time periods to better predict material performance.



J. W. Pitts examines a specimen of porcelain enamel being exposed to outdoor weathering on the NBS Gaithersburg (Md.) grounds. Racks containing asphalt, plastics, and steel are visible.

Rapid, Continuous Monitoring of Hydrogen Chloride



This drawing shows the system devised to continuously monitor hydrogen chloride concentrations in gaseous and aerosol mixtures.

A Simple, Rapid Method[1] of continuously monitoring hydrogen chloride in gaseous and aerosol mixtures has been devised by T. G. Lee of the NBS Institute for Applied Technology. It is particularly useful in determining HCl concentrations in smoke from burning chlorocarbon polymers. Measurement of the toxic gas production properties of such materials is important for applications in homes, aircraft cabins, ships, and other potential fire hazard areas.

In the operation of the system, a pump draws the gas sample at a controlled rate through a gas scrubber, where HCl is absorbed by water. The resulting solution then flows to a detector cell. A potentiometric output from a chloride ion and reference electrode, which is a function of HCl concentration in the sample, is continuously recorded. The system reaches 99 percent equilibrium in 1.5 minutes and is capable of detecting HCl in quantities as small as 20 ppm.

The main components of the system are the detector cell and the gas scrubber. The detector cell consists of a standard calomel-potassium chloride reference electrode with fiber junction and a chloride ion-selective electrode of the liquid-liquid membrane (ion exchange) type. To avoid possible contamination of chloride ions from the reference electrode, a salt bridge using a 1.0 mol potassium fluoride solution connects the two electrodes.

The gas scrubber is a bead column consisting of a 13-mm (i.d.) glass tube packed to a height of about 30 mm with 2-mm glass beads whose surfaces were roughened by a hydrofluoric acid treatment. Following the scrubber are a plenum, filter, drier, and rotameter, which stabilize and monitor the sample flow rate.

A two-barrel push-pull syringe pump driven by a synchronous motor and gear train withdraws the solution from the bottom of the detector cell and also delivers distilled water to the top of the scrubber.

Water is injected into the bead column as rapidly falling, but separate, droplets. As a result of equal delivery and withdrawal rate, the volume of water retained in the scrubber for absorption remains constant during a run. This volume is adjusted to provide optimum absorption efficiency and response time and to avoid entrainment of water by the gas sample beyond the packing.

This simple, rapid procedure for detecting HCl appears to have suitable time response and dynamic range to benefit studies on the smoke and gaseous production properties of materials. It also seems likely that other types of ion-selective electrodes, such as those for bromide, cyanide, and the like, could be used in a similar manner for the analysis of water-soluble components in either gaseous or aerosol samples.

[1] Lee, T. G., A system for continuously monitoring hydrogen chloride concentrations in gaseous mixtures using a chloride ion-selective electrode, Anal. Chem. 41, 391 (Feb. 1969).

CONFERENCE *Briefs*

1969 PARTICLE ACCELERATOR CONFERENCE

New basic fields of study are opening up in the particle accelerator field, according to leading scientists who presented their efforts to an international audience at the Particle Accelerator Conference held in Washington, D.C., from March 5–7, 1969. The Conference was the central meeting place for approximately 800 scientists—over 100 of them attending from countries outside the U.S.A.

Basic research using particle accelerators is of such importance to government and industry that several organizations now sponsor this biennial event. Sponsors for the 1969 Conference included the American Physical Society, the Nuclear Science Group of the Institute of Electrical and Electronics Engineers, the NBS Center for Radiation Research, the National Science Foundation, and the U.S. Atomic Energy Commission. Organization of the Conference was provided by the IEEE and NBS, with J. A. Martin of the Oak Ridge National Laboratory serving as Conference Chairman.

Linear and cyclic accelerators, which have been so fundamental a tool to basic physical research, are now being adapted to provide a wider variety of uses. As the mass spectrometer has revolutionized the atomic physics field, so now it appears that superconducting accelerators, heavy ion accelerators, and electron ring accelerators will provide radical changes in the outlook of nuclear and particle physics.

The technical program included a total of 10 sessions and a dinner session, held the second evening. The main speaker for the evening session was the Honorable Craig Hosmer, Congressman from California and member of the Joint Committee on Atomic Energy. Mr. Hosmer expressed his interest and enthusiasm in the advancement of basic research, and described presidential and congressional feelings encouraging the increased activity in this field. He stressed the importance of scientific professional pride and unity, hoping that the scientific community would take greater pains to manifest the importance of their efforts to the benefit of the "funding" public.

C. O. Muehlhause, director of the NBS Center for Radiation Research, offered the welcoming address.

The first session was a general plenary session chaired by G. K. Green of the Brookhaven National Laboratory. General discussions included the state-of-the-art of particle accelerators, both here and abroad, and the present advances in particular accelerators, such as the new 200 GeV accelerator at the National Accelerator Laboratory, and the electron ring accelerator at Lawrence Radiation Laboratory.

Two Russian invited papers introduced some major technical advances to the scientific community. The first paper, by Yu. M. Ado of the Institute of High Energy Physics, Serpukhov, U.S.S.R., discussed the start-up and successful operation of the 70 GeV proton synchrotron—to date the world's largest working accelerator.

The second paper, by V. P. Sarantsev of the Joint Institute for Nuclear Research, Dubna, U.S.S.R., announced the successful formation, compression, and acceleration of an electron ring to a velocity of three-tenths the speed of light.

The second session was one of two simultaneously held meetings during the first afternoon of the Conference. This was a session on Ion Sources, High Voltage Equipment, DC Accelerators, and Operating Machines, and was chaired by R. G. Herb of the University of Wisconsin. Again the outstanding topics of discussion were heavy ion accelerators, electron ring accelerators, and also tandem accelerators.

Beam Dynamics were discussed in the second simultaneously held session (session three), chaired by E. D. Courant of the National Accelerator Laboratory and Brookhaven National Laboratory.

Present and future developments in existing linear and cyclic accelerators consumed the next two simultaneous morning sessions, held the second day of the Conference. L. Rosen of the Los Alamos Scientific Laboratory chaired the fourth session on Linear Accelerators, while M. S. Livingston of the National Accelerator Laboratory chaired session five on Cyclotrons.

Safety mechanisms were part of the discussions of the sixth session entitled Radiofrequency Systems, Safety, Radiation and Remote Handling, chaired by W. B. Lewis of Atomic Energy of Canada, Ltd.

One of the more popular sessions was the seventh, chaired by E. J. Lofgren of Lawrence Radiation Laboratory. The subjects of Magnets (including Superconducting), Power Supplies, and a round table discussion on

Heavy Ion Accelerators also touched on the main topics of concern mentioned earlier. Recent developments in the U.S.A., the U.S.S.R., and England, in superconducting magnets and electron ring accelerators produced great interest, culminating in an extensive examination of heavy ion accelerators through a round table discussion.

The round table discussion began as a series of four short dissertations expressing how various laboratories are approaching the engineering problems of heavy ion accelerators. R. S. Livingston, Oak Ridge National Laboratory, served as moderator. He first mentioned the aims of heavy ion accelerators as a means to produce accelerated ions of as heavy an atomic weight as uranium-238 (the heaviest naturally occurring element), although the heaviest element now accelerated routinely to high enough energies for nuclear use has been argon with an atomic weight of 40. Various acceleration techniques can be used to accelerate ions to high energies: this served as the topic of the panel discussion.

The first of four speakers on the panel was C. Schmelzer of the University of Heidelberg, Germany, who discussed the UNILAC, a three-stage linear accelerator which will accelerate ions of all stable elements to energies of at least 7 million electron volts per atomic mass unit. The UNILAC will have the unique property of easily variable output energies.

R. M. Main, Lawrence Radiation Laboratory, next presented the Laboratory's plans for a major upgrading of their linear accelerator for heavy ions. At present their linac can accelerate argon ions to 400 MeV; the new scheme will permit uranium ions to be accelerated to useful energies.

J. A. Martin of the Oak Ridge National Laboratory discussed methods of accelerating heavy ions by using a tandem Van de Graaff accelerator as the injector for a cyclotron. The arrangement would also enable the acceleration of light ions to energies of several hundred MeV.

P. H. Rose of High Voltage Engineering discussed the combination of an MP-type tandem Van de Graaff accelerator with a TU-type tandem in order to accelerate the heaviest ions to energies high enough for nuclear reactions.

Following the brief speeches, four other scientists from the audience were asked to express their views on the general topic. These included: R. H. Levy, Avco Everett Research Laboratory; Yu. Ts. Oganesian, Joint Institute for Nuclear Research, Dubna, U.S.S.R.; K. Purser, University of Rochester; and G. Hortig, Max-Planck-Institute, Heidelberg, Germany.

Under the title of Computer Uses, Instrumentation, Controls and Vacuum Systems, the eighth technical session discussed the advances in accelerator accessories. This session was chaired by B. B. Cork of the Argonne National Laboratory, and was held in the morning of the last day of the Conference.

Simultaneously, the ninth technical session met at a round table discussion on Booster Injectors, and further discussed New Accelerator Ideas, and Superconducting Accelerators. The session was chaired by G. R. Lambertson of the Lawrence Radiation Laboratory.

The round table discussion was moderated by R. Billinge of the National Accelerator Laboratory. E. D. Courant, National Accelerator Laboratory and Brookhaven National Laboratory, offered the first of five brief talks on the state-of-the-art concerning their specific booster injector systems. Talks followed by J. L. Kirchgessner, Princeton-Pennsylvania Accelerator; K. H. Reich, CERN; W. Hardt, CERN; and J. M. Peterson, Lawrence Radiation Laboratory. An interesting general discussion followed the talks.

The tenth and final session was another plenary meeting held the afternoon of the third day of the Conference. It was chaired by R. S. Livingston of Oak Ridge National Laboratory, and again stressed the importance of superconducting accelerator systems, including in the agenda, a general paper on "Refrigeration for superconducting and cryogenic systems" by T. R. Strobridge of NBS. Other papers were presented from CNEN-Frascati of Italy, CERN of Geneva, Lawrence Radiation Laboratory, Stanford University, and Brookhaven National Laboratory—a truly international closing to a Conference of universal scientific interest.

The proceedings will be published as an issue of the IEEE Transactions on Nuclear Science, made possible by the contributions of the U.S. Atomic Energy Commission and the National Science Foundation. A copy of the proceedings will be sent to each Conference registrant. Others desiring copies may obtain them for $20 each from the Institute of Electrical and Electronics Engineers, 345 E. 47th St., New York, N.Y. 10017.

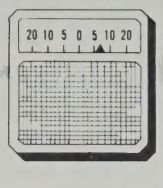
SCHEDULED NBS-SPONSORED CONFERENCES

Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or cosponsored by NBS and will be held at the Bureau's Gaithersburg, Md., facility unless otherwise indicated. These conferences are open to all interested persons unless specifically noted. If no other address is given, inquiries should be sent to the person indicated below in care of Special Activities Section, Room A600, Administration Building, National Bureau of Standards, Washington, D.C. 20234.

Conference on Crystal Growth. Aug. 11–13. Sponsor: American Committee for Crystal Growth. Contact: C. S. Sahagian, Air Force Cambridge Research Laboratories, L. G. Hanscom Field, Bedford, Mass. 01730.

Dental Research—50th Anniversary. Oct. 6–8. Cosponsor: American Dental Association. Contact: G. Dickson (NBS Polymers Division).

3d Materials Research Symposium—Electronic Density of States. Nov. 3–6. Contact: H. C. Burnett (NBS Metallurgy Division).



STANDARDS AND CALIBRATION

STANDARD FREQUENCY AND TIME BROADCASTS

High frequency radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast time signals on the Coordinated Universal Time (UTC) system as coordinated by the Bureau International de l'Heure (BIH), Paris, France. These NBS time signals, UTC(NBS), are maintained within 5 microseconds of the corresponding time signals of the U.S. Naval Observatory, UTC(USNO). The UTC pulses occur at intervals that are longer than one coordinate second by 300 parts in 10^{10} during 1969, due to an offset in carrier frequency coordinated by BIH. To maintain the UTC scales in close agreement with the astronomers' time, UT2, phase adjustments are made at 0000 hours Greenwich Mean Time (GMT) on the first day of a month as announced by BIH. *There will be no adjustment made on July 1, 1969.*

The low-frequency radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses without offset to make available to users the standard of frequency so that absolute frequency comparisons may be made directly, following the Stepped Atomic Time (SAT) system. Step time adjustments of 200 ms are made at 0000 hours GMT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be an adjustment made on July 1, 1969. The seconds pulses emitted from WWVB will be retarded 200 ms.*

NBS obtains daily UT2 information from forecasts of extrapolated UT2 clock readings provided by the U.S. Naval Observatory with whom NBS maintains close cooperation.

1000-PICOFARAD STANDARD CAPACITORS

A considerable improvement in the routine calibration of 1000-picofarad standard capacitors has been achieved recently. The total measurement uncertainty for these high stability, hermetically sealed gas dielectric capacitors at 1000 Hz is now 5 ppm compared to the previous 20 ppm.

This reduction in uncertainty was made possible largely by an overall upgrading of the calibration process, particularly temperature control. The calibration results now include the capacitor's temperature which is accurate within ± 0.1 °C.

All measurements are in terms of the NBS unit of capacitance rather than the defined unit, the absolute farad. The NBS unit is maintained with a group of NBS 10-picofarad quartz capacitors; the unit so maintained is believed to not differ from the absolute farad by more than 3 ppm. The stated total measurement uncertainty of 5 ppm pertains to the whole measurement process starting with the standards which preserve the NBS unit.

An improved calibration is also available at frequencies of 66⅔, 100, and 400 hertz. However, at these frequencies the total uncertainties are somewhat larger than 5 ppm. There will be a continuing effort to decrease measurement uncertainties still further on all high stability standard capacitors calibrations.

These improved calibrations pertain to one of the services listed in section 211.015 of *Calibration and Test Services of the National Bureau of Standards.*[1]

[1] Calibration and Test Services of the National Bureau of Standards, NBS Spec. Publ. 250, 1968 ed., available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $1.75.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Volume 53, No. 4, April 1969, 30 cents. Annual subscription: Domestic, $3; foreign, $4. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, $6; foreign, $7.25. Single copy, $1.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, $5; foreign, $6.25. Single copy, $1.25.

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CURRENT ISSUES OF THE JOURNAL OF RESEARCH

J. Res. Nat. Bur. Stand. (U.S.), **73B,** (*Math. Sci.*), No. 2 (Apr.–June 1969).

Wampler, R. H., An evaluation of linear least squares computer programs.

Dafermos, S. C., and Sparrow, F. T., The traffic assignment problem for a general network.

Abdel Karim, A. I., Sufficient conditions for the instability of numerical integration methods.

Gelman, H., The second orthogonality conditions in the theory of proper and improper rotations. II. The intrinsic vector.

Gelman, H., The second orthogonality conditions in the theory of

proper and improper rotations. III. The conjugacy theorem.
Newman, M. Subgroups of SL(t,z).
Marimont, R. B., Cuttable and cut-reducible matrices.
Lehner, J., A theorem on automorphic integrals.
Andrews, J. R., and Nahman, N. S., A digital computer technique for calculating the step response of lumped or distributed networks.
Saaty, T. L., Symmetry and the crossing number for complete graphs.

OTHER NBS PUBLICATIONS

Bean, B. L., and Dise, J. R., Causes of variation in chemical analyses and physical tests of portland cement, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 17, 32 pages (March 1969), 40 cents.
Beeghly, H. F., Cali, J. P., and Meinke, W. W., Eds., Nuclear standards for chemistry and technology. Proceedings of a Symposium on Standards in Nuclear Chemistry and Technology held at the 156th National Meeting of the American Chemical Society, Atlantic City, N.J., September 8–9, 1968, Nat. Bur. Stand. (U.S.), Spec. Publ. 310, 261 pages (Dec. 1968), $1.25.
Blaine, R. L., Arni, H. T., and Evans, D. N., Interrelations between cement and concrete properties, Part 4, Shrinkage of neat portland cement pastes and concretes, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 15, 79 pages (March 1969), 75 cents.
Braun, W., and Carrington, T., Line emission sources for concentration measurements and photochemistry, Nat. Bur. Stand., (U.S.), Tech. Note 476, 23 pages (March 1969), 30 cents.
Gosman, A. L., McCarty, R. D., and Hust, J. G., Thermodynamic properties of argon from the triple point to 300 K at pressures to 1000 atmospheres, Nat. Bur. Stand. (U.S.), Nat. Stand. Ref. Data Ser. 27, 153 pages (March 1969), $1.25.
Greenfeld, H. H., The performance of roofing made with asplund felts, Nat. Bur. Stand. (U.S.), Tech. Note 477, 27 pages (March 1969), 35 cents.
Ku, H. H., Ed., Precision measurement and calibration. Statistical concepts and procedures, Nat. Bur. Stand. (U.S.), Spec. Publ. 300, Volume I, 436 pages (Feb. 1969), $5.50.
LaFleur, P. D., Ed., Activation Analysis Section: Summary of activities July 1967 to June 1968, Nat. Bur. Stand. (U.S.), Tech. Note 458, 109 pages (March 1969), $1.
Wegstein, J. H., A semi-automated single fingerprint identification system, Nat. Bur. Stand. (U.S.), Tech. Note 481, 23 pages (Apr. 1969), 30 cents.
Yakowitz, H., Michaelis, R. E., and Vieth, D. L., Standard Reference Materials: Homogeneity characterization of NBS spectrometric standards IV: Preparation and microprobe characterization of W-20% Mo alloy fabricated by powder metallurgical methods, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-16, 30 pages (Jan. 1969), 35 cents.

PUBLICATIONS IN OTHER JOURNALS

This column lists all publications by the NBS staff, as soon after issuance as practical. For completeness, earlier references not previously reported may be included from time to time.

Bay, Z., and Luther, G. C., Locking a laser frequency to the time standard, Appl. Phys. Letters **13,** No. 9, 303–304 (Nov. 1968).
Cuthill, J. R., McAlister, A. J., Williams, M. L., and Dobbyn, R. C., Soft X-ray spectra and comparison with the theoretical density of states (Proc. Conf. Soft X-ray Band Spectra and the Electronic Structure of Metals and Materials, Strathclyde, Scotland, Sept. 18–21, 1967), Chapter in Soft X-ray Band Spectra and the Electronic Structure of Metals and Materials. Part II. Heavy Metal and Alloy Spectra and Comparison with other Optical Methods, pp. 151–161 (Academic Press Inc., New York, N.Y., 1968).
Dragoo, A. L., Diffusion rates in solids, Chapter IV in Atomic Energy Review, O. Kubaschewski, ed., 2, 187–202 (International Atomic Energy Agency, Vienna, Austria, 1968).
Evans, J. P., and Sweger, D. M., Immersion cooler for freezing ice mantles on triple-point-of-water cells, Rev. Sci. Instr. **40,** No. 2, 376–377 (Feb. 1969).
Fatiadi, A. J., Esters of benzenepentol (pentahydroxybenzene), J. Chem. Eng. Data **14,** 118–119 (1969).
Hall, J. L., The laser absolute wavelength standard problem, IEEE J. Quantum Elect. **QE–4,** No. 10, 638–641 (Oct. 1968).
Hummer, D. G., Non-coherent scattering-IV. Doppler redistribution functions in moving atmospheres, Monthly Notices Roy. Astron. Soc. **141,** 479–488 (Dec. 1968).
Iverson, W. P., Mechanisms of microbial corrosion (Proc. First Intern. Biodeterioration Symp., Southampton, England, Sept. 9–14, 1968), Chapter in Biodeterioration of Materials. Microbiological and Allied Aspects, pp. 28–43 (Elsevier Publ. Co., Ltd., Essex, England, 1968).
Milligan, D. E., Jacox, M. E., and Guillory, W. A., Matrix-isolation study of the vacuum-ultraviolet photolysis of trifluorosilane. The infrared spectrum of the free radical SiF_3, J. Chem. Phys. **49,** No. 12, 5330–5335 (Dec. 1968).
Moore, G. A., Wyman, L. L., and Joseph, H. M., Comments on the possibilities of performing quantitative metallographic analyses with a digital computer, Chapter 13 in Quantitative Microscopy, pp. 380–403 (McGraw-Hill Inc., New York, N.Y., 1968).
Robbins, C. R., Growth of strontium titanate from a silica flux, J. Crystal Growth **2,** 402–404 (1968).
Rush, J. J., Melveger, A. J., Farrar, T. C., and Tsang, T., Laser-Raman spectra and hindered rotation in the phosphonium halides, Chem. Phys. Letters **2,** No. 8, 621–624 (1968).
Schweitzer, W. G., Jr., Saturated absorption by neon inside a 6328 Å laser with a mixture of neon isotopes in its gain tube, Appl. Phys. Letters **13,** No. 11, 367–368 (Dec. 1968).
Shumaker, J. B., Jr., Franck-Condon factors for high rotational levels of nitrogen, J. Quant. Spectry. Radiative Transfer **9,** 153–156 (1969).
Vieth, D. L., Yakowitz, H., Tensile loading device for Kossel microdiffraction and metallography, Rev. Sci. Instr. **39,** No. 12, 1929–1931 (Dec. 1968).
Watson, T. W., and Flynn, D. R., Thermal conductivity and electrical resistivity of beryllium copper foil, Trans. Met. Soc. AIME **242,** 876–880 (May 1968).
Watson, T. W., and Flynn, D. R., Thermal conductivity of four heat-resistant alloys, Trans. Met. Soc. AIME **242,** 844–846 (May 1968).
Wiederhorn, S. M., The influence of water vapor on crack propagation in soda-lime glass, J. Am. Ceram. Soc. **50,** No. 8, 407 (1967).
Wiese, W. L., Transition probabilities for prominent Ar I lines (Proc. 8th Intern. Conf. on Phenoment in Ionized Gases, Vienna, Austria, Aug. 27–Sept. 2, 1967), Book, 8th International Conference on Phenomena in Ionized Gases, p. 447 (Springer-Verlag, Vienna, Austria, Sept. 1967).
Williams, E. S., A voltage converter for a new era, Meas. Data **2,** No. 6, 75–79 (Nov–Dec. 1968).
Wyckoff, J. M., Radioactivity produced by a linac, IEEE Trans. Nucl. Sci. **NS–14,** 990 (June 1967).

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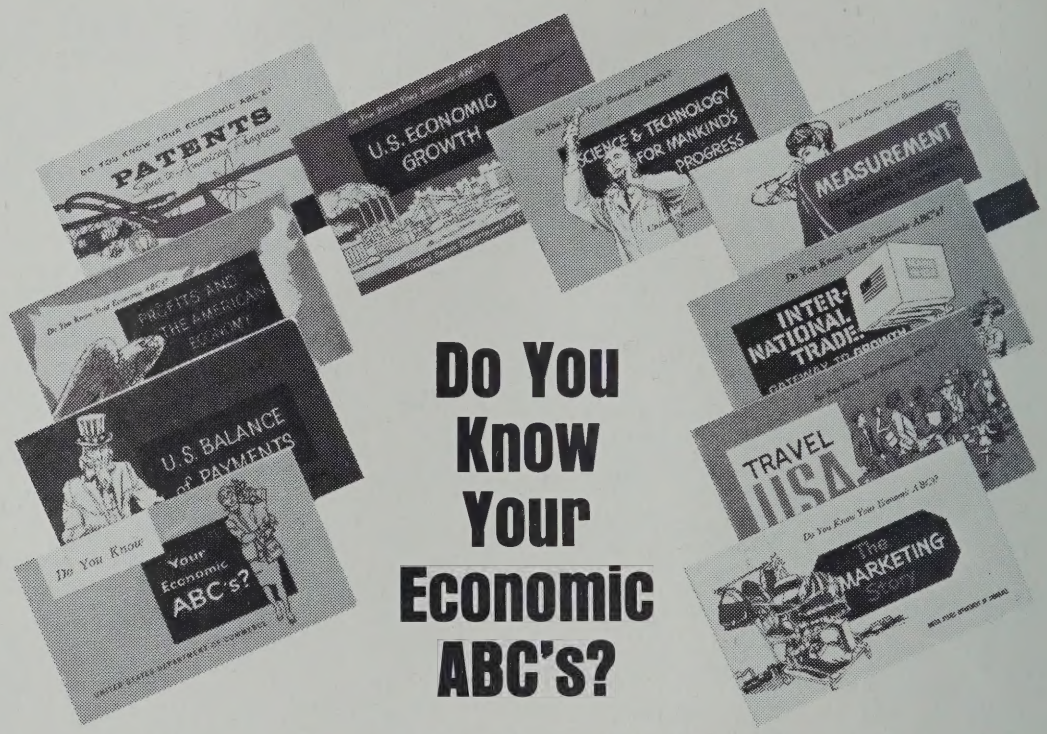

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